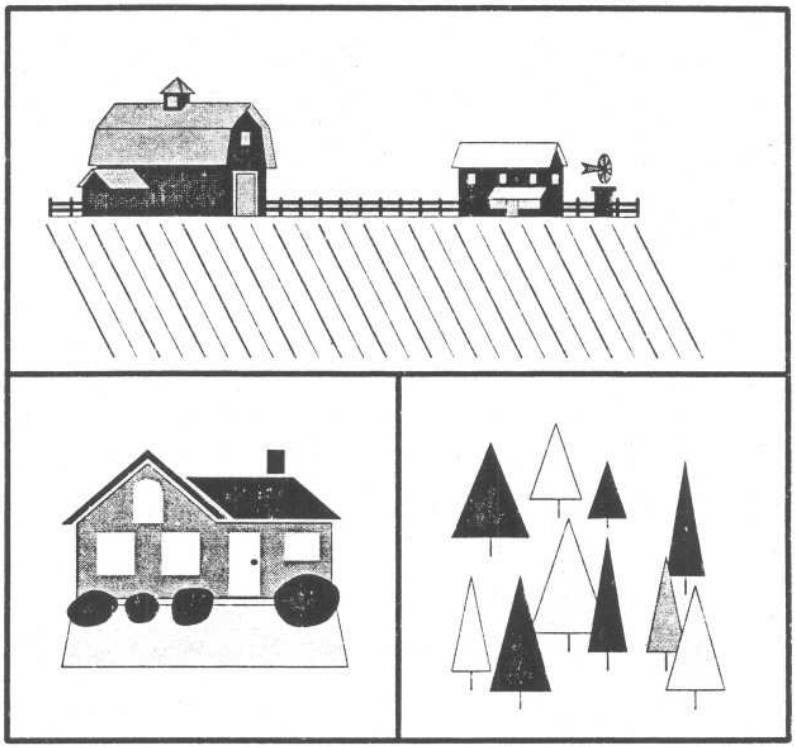
BUREAU OF WATER

South Carolina Department of Health and Environmental Control

Beneficial Use of Wastewater Biosolids

SOUTH CAROLINA GUIDE ON LAND APPLICATION OF WASTEWATER SLUDGE



February 1996

A joint project:
DHEC & Clemson University

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PREFACE

Context. In 1987, DHEC published a document entitled *Land Application of Sludge Guidance Manual,* the State's initial effort to provide guidance on the beneficial use of wastewater biosolids. The *Land Application of Sludge Guidance Manual,* dated December 1987, has provided the regulatory community with:

- Helpful information on developing land application projects
- Insight on issues relating to the permitting process

With several years of experience in permitting land application sites, and with the establishment of federal regulations (reflected in the code of federal regulations (CFR)) on the management of sludge, DHEC completed this guidebook to replace the *Land Application of Sludge Guidance Manual.* Guidance is provided on implementing 40 CFR 503 on sludge management and developing programs to beneficially use wastewater sludge from both domestic and industrial sources. This information can guide permit applicants through the permitting process at DHEC.

This document is not intended to supersede any applicable State or Federal regulation (e.g., 40 CFR 503, 257 and R61-9). Rather the information is guidance and reflects only a summary of regulatory requirements at the time of publishing. At the time of publishing, DHEC has proposed state regulations addressing these issues before the legislature for approval (i.e., amendments to R.61-9).

Scope. This guide focuses on management of biological sludge from domestic and industrial treatment systems. The following are not addressed: Septage, grit, screenings, sludge from water treatment systems and sludge from physical/chemical wastewater treatment systems.

In this guide, the term "sludge" is typically referred to as wastewater biosolids. While the federal regulations refer to "sewage sludge", many EPA and trade association publications are using the term biosolids.

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Land Application Overview

✏ Perspectives on Beneficial Use

Land application of wastewater biosolids is beneficial when done properly. In many situations it is the most environmentally sound and cost-effective management approach. Wastewater biosolids consist of water, soluble substances, and solids. Land application is a form of recycling, because it allows recovery of elements needed for crop production. Thus land application can benefit farmers by offsetting the costs of fertilizer or lime, while benefitting everyone because of reducing the pressure on existing landfills.

Crops can benefit from land application

Land application requires management of the land to produce crops, forest products, etc., otherwise no recycling occurs. For the system to function properly, the soil is well managed and crops are harvested and removed from the site regularly. Good management includes maintaining the soil pH in the proper range and providing plant nutrients according to need. Nutrient needs can be based on Clemson Extension Service recommendations that follow soil test results.

Questions naturally arise from the public on whether the practice is really safe for their community. The best scientific evidence shows that wastewater biosolids can be applied to agricultural lands, home gardens, lawns, and forests, with no detrimental effects. Regulations developed by the United States Environmental Protection Agency (EPA) and these guidelines provide direction to provide reasonable assurance that public health and the environment will be protected. To be land applied, wastewater biosolids must have been treated to reduce pathogens, reduce the potential to attract vectors, and meet minimum requirements for pollutants.

The Soil-Crop System. The soil-crop system has a large capacity to assimilate and benefit from the constituents contained in wastewater biosolids. However, the capacity is not infinite. The nitrogen content of non-alkaline stabilized wastewater biosolids is often the factor that determines the amount of wastewater biosolids that can be applied to land.

Greater rates may impact ground water quality. With alkaline-stabilized wastewater biosolids, the calcium-carbonate equivalent will probably be the factor that determines the quantity that can be applied per acre. With these, wastewater biosolids applications should be based on the lime requirement recommendations as given by soil test. Application of too much lime may reduce crop production and effectiveness of the recycling. This would also affect the conditions upon which risk assessment of pollutant behavior was based.

✏ Agronomic Rate as a Goal

For beneficial use of wastewater biosolids, while maintaining environmental quality, the goal is to match the application rate with the crop need, i.e., agronomic rate. The agronomic rate is the amount of dry wastewater biosolids that can be applied to a specific crop within an appropriate time period. A working definition would be:

The Agronomic Rate . . .

1) Provides the amount of nitrogen needed by a crop while minimizing the amount of nitrogen that passes below the crop's root zone, and/or
2) Provides the appropriate amount of other plant nutrients or lime that promotes crop growth.

Since the organic nitrogen in wastewater biosolids is not as readily available to crops as is the nitrogen in commercial fertilizer, the agronomic loading rate or plant available rate must be estimated. Organic nitrogen in wastewater biosolids is made available to crops as the wastewater biosolids are decomposed by soil microorganisms. Decomposition of wastewater biosolids is faster when soil is warm and moist, slower when soil is cool and dry. Calculation of the agronomic loading rate requires that an estimate of wastewater biosolids decomposition rate be used. This is also referred to as the mineralization rate. The lower the mineralization rate, the a greater quantity of wastewater biosolids will be needed to supply a given amount of plant available nitrogen. However, eventually all the nitrogen in the wastewater biosolids will be mineralized. Thus if lower mineralization rates are used in calculating the agronomic rate, higher amounts of residual nitrogen remain and need to be

Organic nitrogen ... is not as readily available to crops ... as commercial fertilizer

accounted for if land application is repeated each year or more than one application is made in a single year.

Agronomic rate implies that the wastewater biosolids are applied when the crop can use the nitrogen. For example, wastewater biosolids should be applied within a month or two of planting corn in the Coastal Plain of South Carolina. Other crops, such as fescue, have a much wider "window" of application times because of their long growing season. Application at inappropriate times may result in ground water quality being affected by excess nitrogen. An exception to this may be with alkaline-stabilized wastewater biosolids. In that case, nitrogen is not typically the limiting factor and therefore the timing of the application is not as critical.

Agronomic rate implies that the wastewater biosolids will be applied at an appropriate time

Beyond Nitrogen. Aside from nitrogen, alkalinity (measured as calcium-carbonate equivalent) will likely determine the agronomic rate for wastewater biosolids that have been alkaline stabilized. Lime is commonly applied to crop land to counter-act soil acidification which occurs naturally in areas where precipitation exceeds soil water losses through evaporation and crop transpiration. Soil acidification also results from use of fertilizers and wastes that contain amino-forms of nitrogen. Lime neutralizes soil acidity. Alkaline wastewater biosolids have the same effect.

Crops perform best when soil pH, an index of acidity, is maintained in agronomic ranges. The agronomic range depends on the land usebut in general is between 5.0 and 7.0. Soil test should be performed on a periodic basis to verify soil pH.

Sometimes potassium or magnesium could be present in high enough concentrations to determine the agronomic rate. For some industrial wastewater biosolids, boron may limit the agronomic rate. The Clemson University Cooperative Extension Service or experts in crop and forest products production (such as Certified Crop Consultants, soil scientists, or registered foresters) can provide guidance on optimum pH and agronomic rate for a land application system.

✏ Environmental Protection Issues

Before wastewater biosolids can be considered for land application, it must be treated to reduce pathogens and the potential to attract flies and other organisms that could transmit disease-causing agents — unless the material doesn't have the potential for these problems (e.g., some industrial material). Also, wastewater biosolids can't exceed certain limits of metal pollutants. The purpose of these limits is to prevent build-up or

pass-through of metals that could lead to crop or ground water pollution.

When best management practices, regulations and guidelines are followed, the chances of environmental impacts or public health problems are minimal. This is based on a sense that current regulations (i.e., federal "503" regulations) were developed using a conservative risk assessment. While these regulations address domestic "sewage sludge," DHEC believes that the risk assessment reasonably applies to wastewater biosolids from the biological treatment of industrial wastewater.

Evaluating Risk. During the development of the 503 regulations, the best scientific talent was assembled to establish land application standards using the best data available. The assessment was comprehensive and conservative. In all, the potential risk of 25 pollutants via 14 different public health and environmental pathways were evaluated. In addition, a national survey of the characteristics of wastewater biosolids was conducted to determine typical levels of pollutants in these materials.

The EPA risk assessment in the 503 regulations was both comprehensive and conservative

Under regulation 40 CFR 503, requirements are placed on certain metals, termed "pollutants", and pathogens. In addition, vector attraction reduction is addressed. Depending on the level of treatment of wastewater biosolids, different regulatory controls apply. Whether control of important components comes through pre-application treatment or post-application access and use, the land application requirements reasonably insure protection of public health and the environment.

✏ Role of EPA and DHEC

The 503 regulations regarding land application are based on wastewater biosolids being applied at agronomic rates — except for reclamation projects. However, recommendations about how to compute the nitrogen needs were not made. EPA recognized the variety of issues that factor into establishing nitrogen-based application rates. Determining agronomic rate was viewed as an issue to be dealt with on a case-by-case basis by the state permitting authorities.

Since the 503 regulations were published by EPA in 1993, EPA has been the responsible government entity for compliance with the regulation. DHEC is pursuing delegation of the program to the state level.

DHEC has authority under the State's Pollution Control Act, the Solid Waste Policy and Management Act and R61-9 to issue permits for land application of wastewater biosolids. Often,

DHEC's permitting of land application programs is done in conjunction with the applicant's NPDES permit. Since the federal 503 regulation is a "self-implementing" regulation, wastewater facility owners typically only need to receive a permit from DHEC. However, federal compliance with the 503 regulation is an issue between the facility owner and EPA Region IV, and EPA can require permits at their discretion. For example, there are application and reporting requirements to EPA in Atlanta as an independent issue from State permitting. For more information contact one of the following:

- Vince Miller, EPA's Region IV Coordinator
  Phone: 404-347-3012, ext. 2953
- Mike Montebello, DHEC's Domestic Wastewater Contact
  Phone: ~~803-734-5300~~ 803-898-4228
- Andy Yasinsac, DHEC's Industrial Wastewater Contact
  Phone: ~~803-734-5300~~

Development of a Management Program

✏ THE NEED FOR PLANNING

Planning for management of wastewater biosolids is as important as planning for the wastewater treatment system itself. In some cases, as much as half of the entire cost for construction and operation can be devoted to residuals management. Dealing with wastewater biosolids should not be an "after thought."

In many cases, wastewater operations staff lean on consultants to determine and assist in implementing cost-effective strategies. Regardless, time spent planning is well spent.

Planning fosters success

✏ WASTEWATER BIOSOLIDS CHARACTERISTICS

Before a wastewater biosolids management program can be developed, the material must be characterized. Analyses of nitrogen and metal contents, alkalinity, and pathogens are vital to estimating the agronomic rate and documenting the suitability of the material for land application. As a by-product of wastewater treatment, wastewater biosolids composition can vary. Therefore, it is vital to provide adequate monitoring to establish the content and variability of a wide range of pollutants and beneficial constituents.

It is vital ... to establish the content and variability of the material

The more variable the material, the more frequently it should be monitored to avoid large errors in estimating agronomic rate and metal loading of soil. For example, inadequate monitoring can result in too much or too little nitrogen being applied. The unintended and undesirable consequences being poor crop performance and/or pollution of soil and water.

When establishing a monitoring protocol, consider the possibility of seasonal variability of characteristics. Since wastewater treatment operations are affected by temperature, wastewater biosolids characteristics can vary between winter

and summer. Also, for industrial operations, wastewater biosolids characteristics may vary depending on production.

The better the understanding of wastewater biosolids characteristics, the more potential for success in a program.

✏ Effect of Pre-application Treatment

Wastewater biosolids characteristics (e.g., level of pathogens) play a direct role in establishing options for beneficial use. For example, some wastewater biosolids that have been treated to "further" reduce pathogens can be applied with few restrictions.

A wastewater biosolids manager should weigh the benefits of maximizing pre-application treatment. In general, the higher the treatment provided for wastewater biosolids, the greater the options for beneficial use. In addition, wastewater biosolids which are treated to high standards are less likely to be controlled based on current regulatory frameworks of EPA and DHEC. The program manager desiring to minimize regulatory oversight should pursue a management system which attains minimal levels of pathogens/metals and maximum vector attraction reduction.

Greater treatment levels offer application flexibility

Some communities may prefer to reduce wastewater biosolids treatment costs — making a trade-off for additional site and application restrictions. Either choice is acceptable. Consider the following two examples:

Topic	City #1	City #2
Level of Treatment	High	Minimum
Permitting by DHEC	One-time program approval. Notify DHEC of application	Each site approved requires permit modification
Site restrictions	Limited	Substantial
Capital Cost	Higher	Lower
Environmental Risk	Low	Low
Regulatory Controls	Limited	High

In summary, greater treatment levels offer increased application flexibility. Both options provide for protection of public health and the environment.

✏ Crop Management Choices

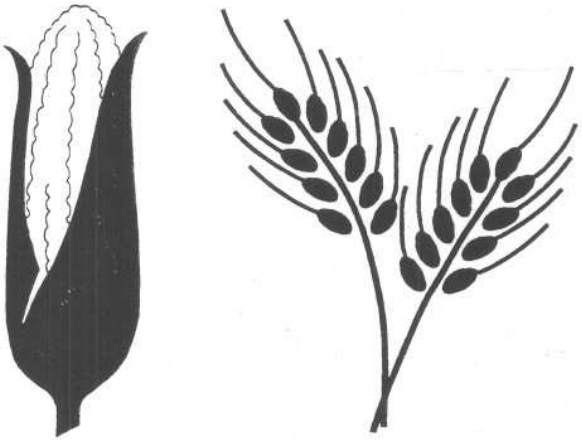
One management challenge is identifying appropriate sites to match the continuing production of wastewater biosolids. While the timing of plant uptake of nitrogen is seasonal, wastewater treatment operations staff often must manage wastewater biosolids on a day-to-day basis. When sites are not available or the timing is such that the crop has no demand for nitrogen, storage of wastewater biosolids is required.

The amount of storage capacity required is a function of the land area available and the crops growing on that land. Over short time periods, any land will have restricted access due to weather conditions. The more land available and the longer the growing season of the crops, the lower the cost for storage facilities. The right choices can reduce storage costs.

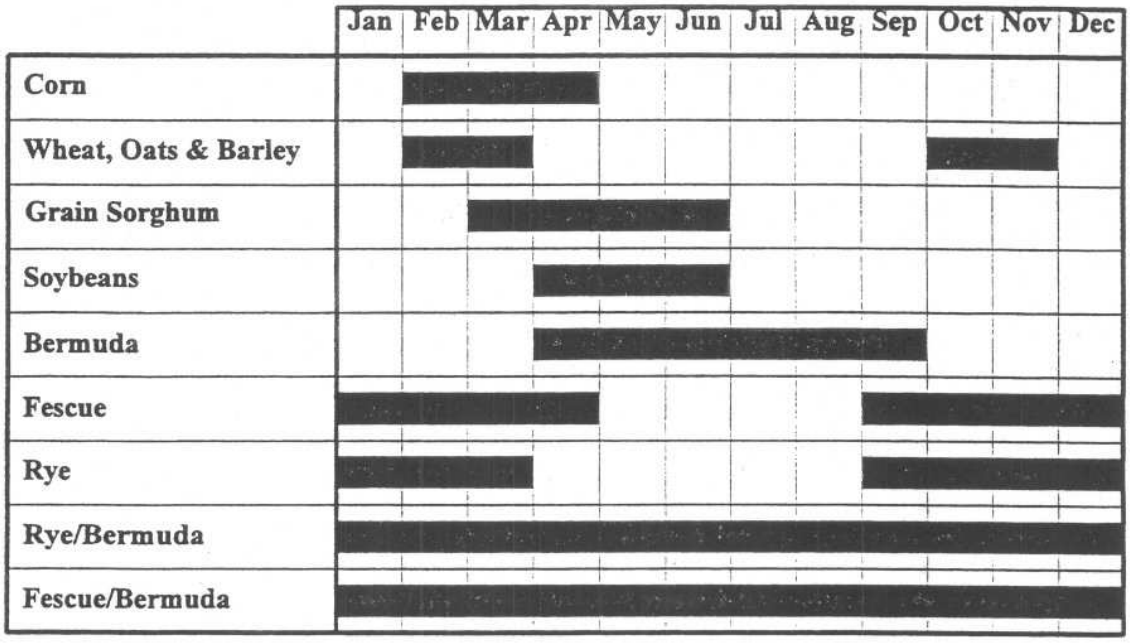
The right choices can reduce storage costs

For example, program managers may not want to rely on row crops for application since the application timing is generally limited. It is better to identify a set of sites with multiple crops to provide more options for beneficial use. Another approach is to identify sites with the capability to support both winter and summer grasses, for year-round land application capability.

Securing sites with a variety of crops can provide flexibility to treatment system operators who feel pressure to efficiently manage wastewater biosolids at their plant sites. A program which relies exclusively on row crops, for example, will result in limited times during the year when wastewater biosolids can be applied. Many entities have found success by using pasture lands with a summer/winter combination of bermuda and fescue. Such sites offer a wider "window" for land application. Whatever the combination, choosing a variety of crops is essential to a flexible management program. Samples of recommended application "windows" are shown as follows:



The type of crop can have a great deal to do with operational flexibility of the wastewater system.



- *Application periods may vary slightly annually as a function of rainfall, temperature and other factors.*
- *The above list is representative and not exhaustive. For recommended schedules for crops and/or combinations not listed, consult the Clemson Agronomy & Soils Dept. or County Extension Agent in your area.*

For forest applications, generally applications can be made to pine trees year round. Hardwoods should be limited to the warmer months of April - September.

✏ Application Sites

Wastewater biosolids are land applied on a variety of sites, including:

- Agricultural Land (private/public-owned)
- Forest Land
- Public Areas
- Reclamation Sites

➨ *Agricultural Land:* The most common site is privately-owned agricultural land with the primary purpose of crop production. For use of wastewater biosolids on these sites, wastewater treatment facility staff or consultants coordinate applications to fit into the needs of the existing agricultural operation.

Site Selection. Fields selected for land application should be capable of normal agricultural production. Fields on which reasonable yields have been obtained for several years are often quite suitable for application.

Inspection of a potential field is normally made by a qualified soil scientist to verify that the field is suitable for the growth of crops. Typically, soil borings are made to confirm an adequate root zone exists for reasonable crop growth. Depth to bedrock must be enough to allow for normal tillage and planting operations. The soil or soils within the field should be adequately drained to allow wastewater biosolids application and normal field operations. Soils classified as poorly drained are usually inappropriate unless artificial drainage provisions have been made (e.g., ditches or tiles).

Inspection of a potential field is normally made by a qualified soil scientist

It is not the case that any agricultural field is acceptable for land application. Many fields are poorly managed and the crops readily show it. For example, pastures or hayfields with thick stands of broomsedge have been poorly managed. Actively managed fields where the yields are significantly less than the county average are not ideal land application sites.

Regional Considerations. With a wide range of major soil types in South Carolina, it is important to consider their differences.

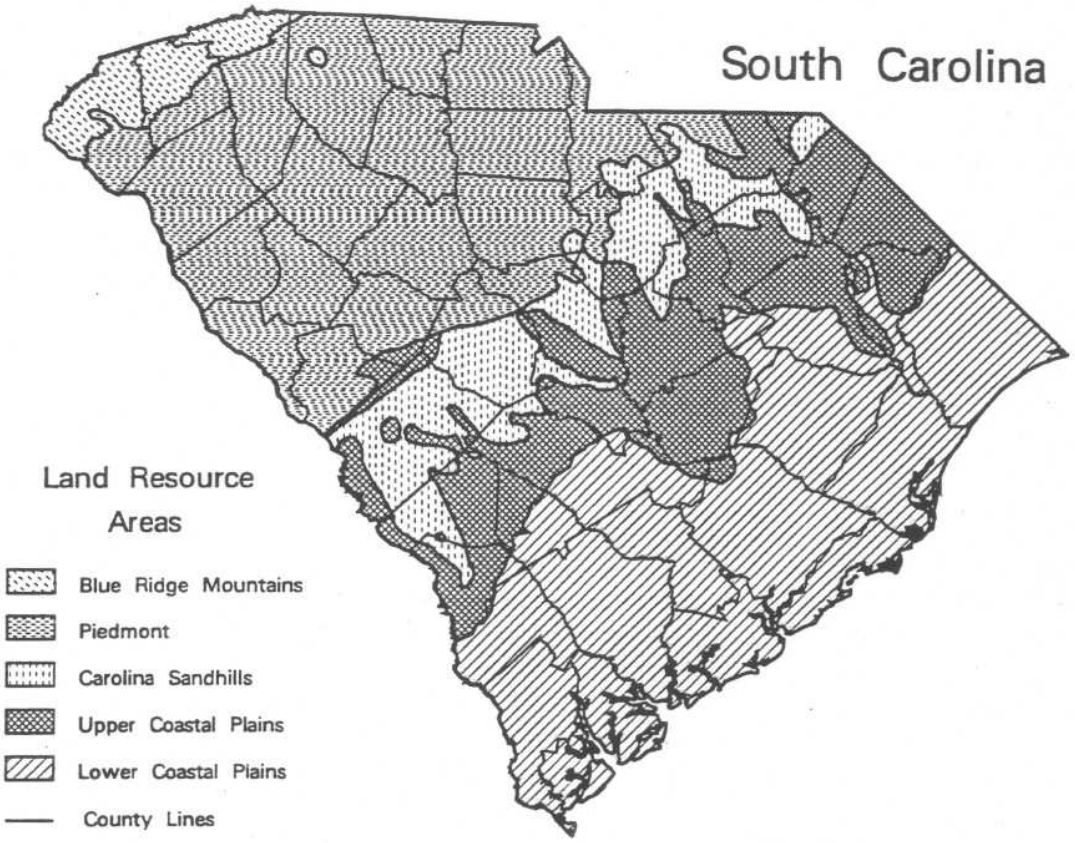
Four major regions to consider include:

- Piedmont and Mountains
- Sandhills
- Upper Coastal Plain
- Lower Coastal Plain

One of the primary purposes in making regional distinctions is to insure the protection of the ground water. In certain areas of the state, soils and depth to ground water require more intensive management practices to insure that significant nitrate is not leached or pulsed to the ground water.

While the Piedmont and Mountain regions usually do not warrant special considerations for groundwater concerns, attention to certain issues should be given in other regions.

SANDHILLS AND UPPER COASTAL PLAIN: Soils with deep sand surfaces, having a clay layer deeper than 20 inches, have low inherent productivity and are generally not suited for rowcrop production unless irrigated. When used for crop production, they are better suited to coastal bermuda and other warm season forages. Soils having a clay layer within 20 inches of the surface are suitable for rowcrop production with good management.



Nitrogen applications to coastal bermuda should be split into four or more applications, whether the source is commercial fertilizer or wastewater biosolids. One-fourth of the annual application should be made when growth begins in the spring and after each harvest. This management technique supplies adequate nitrogen to the forage and helps to avoid excessive leaching of mineralized nitrogen.

LOWER COASTAL PLAIN AND SIMILAR AREAS: Soils having a seasonal water table within 30 inches of the surface require careful nutrient management to avoid excessive loss of mineralized nitrogen to ground water. Applications should only be made when the water table is greater than 30 inches from the surface and then annual applications should be split as recommended for deep sands to avoid contamination of ground water.

➨ ***Forest Land:*** Since significant forest land exists in South Carolina, such land may be an important resource in planning for the beneficial use of wastewater biosolids. The agronomic rate, application schedule, and management considerations for forest sites are somewhat different from typical agricultural sites.

It is recommended that forest stands be fully stocked, vigorously growing and be at or near canopy closure (normally after 5-10 years from planting), to maximize nutrient uptake. To aid in runoff reduction and erosion control, it is recommended that an adequate forest floor (greater than ½ inch of leaf litter) have been established over 80% of the site. Generally, a sufficient forest floor exists when canopy closure is reached. Depth to the seasonal-high water table should be addressed in a similar fashion as with agricultural sites.

Management considerations for forest sites are somewhat different

Wastewater biosolids applications are usually scheduled based on soil pH, metal loading rates, nutritional needs of the tree crop, and equipment accessibility in the stand for effective distribution. Spreading should not be conducted when rutting or excessive soil compaction occurs due to high soil moisture conditions. Applications are usually suitable throughout the year in pine stands, and February through October in hardwood stands. Follow-up vegetation management should be scheduled based on landowner management objectives and crop needs.

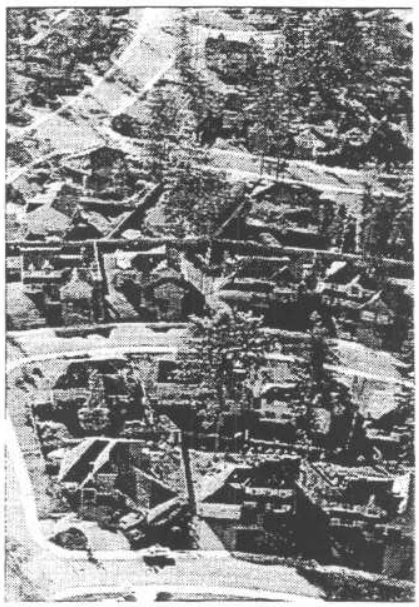
For additional details on application of wastewater biosolids to forest land, suggested contacts include the Forest Resources Department at Clemson University, Area county Extension Agents for Forestry, and professional foresters with training in nutrient management.

➨ ***Public Areas:*** When wastewater biosolids are treated to the highest standards, they can be distributed to users such as:

- Homeowners
- Commercial growers
- Landscapers

Since the material meets the most stringent metal requirements and has been treated to address concerns for pathogens and vector attraction, public use is acceptable.

Wastewater biosolids of this quality can be applied to lawns, gardens, shrubs, parklands, etc. Nationwide, cities have bagged wastewater biosolids, allowed the public and commercial operations to pick up material in trucks and developed distribution programs around other



... useful for lawns, also

strategies. Often, wastewater biosolids distribution to the public involves labelling to identify constituents and recommend application rates.

Generally, distribution programs have met with acceptance from the public and horticultural professionals.

➨ ***Reclamation Sites:*** Wastewater biosolids can be a helpful resource in returning barren land to productivity. Application is typically a one-time project, with the rate higher than the agronomic rate, consistent with 40 CFR 503.

Usually, wastewater biosolids are incorporated into the soil and the land is reseeded. Prompt revegetion is important in preventing erosion.

Reclamation sites may include:

- Surface mine spoils
- Borrow pits
- Cleared forests
- Closed out landfills

OTHER ISSUES FOR ALL SITES. Potential for runoff should be evaluated. When surface application is planned, sites should have a slope of less than 10% for pasture and hayland, and a slope of less than 8% for rowcrops. Surface applications may be made on steeper slopes if the land is in forage and has been terraced such that runoff from the field is normally prevented. Wastewater biosolids may be injected on sites with slopes greater than 10%. Regardless, wastewater biosolids should not be applied to fields where the potential for runoff is high.

When evaluating potential sites, it is important to evaluate the site's proximity to and potential impact on:

- ➨ Adjacent property
- ➨ Surface Waters
- ➨ Homes
- ➨ Potable Wells
- ➨ Drainage Ways
- ➨ Roads

✏ APPLICATION RATE ISSUES

The application rate should not exceed the agronomic rate of the specific crop being grown. The agronomic rate is usually determined by either the nitrogen content or the alkalinity. In rare situations the agronomic rate may be determined by the content of other plant nutrients such as phosphorus, potassium, or magnesium, or by the sodium content. Such exceptional situations can be identified by a soil scientist or agronomist review of soil test information and the chemical analysis of the waste. In some cases, metals identified in the 503 regulations

The rate is usually determined by either nitrogen or alkalinity

may be the limiting constituent. Since these situations are not common, only cases in which nitrogen or alkalinity limit the agronomic rate will be discussed here.

Case for Alkalinity. The agronomic rate based on alkalinity is related to the potential for the wastewater biosolids to increase the pH of the soil. Soil pH in the desired range is important for crop production as well as to the risk assessments made relating to metal loading limits in soil. For best results, soil pH should be in the ranges below:

Crop	pH
Alfalfa & short-stake tomatoes (Piedmont)	6.5-7.0
Clovers, vegetables, fruit & nuts	6.0-6.5
Christmas trees, pine, tobacco, Irish potatoes, sweet potatoes, centipede & carpetgrass	5.5-6.0
Blueberries	5.0-5.5
Pine trees	5.0-7.0
Hardwoods and other Crops	5.8-6.5

From Lime and Fertilizer Recommendations Based on Soil-Test Results, Circular 476, Cooperative Extension Service, Clemson University, Clemson, 1982

The agronomic rate based on alkalinity must be determined by soil test, which will indicate the lime required to raise the pH of the soil to the desired range and the calcium-carbonate equivalent of the wastewater biosolids. For example, if the soil test indicates that the lime requirement of the soil is 1.5 tons of lime/acre, and the calcium-carbonate equivalent of the wastewater biosolids is 50%, then the agronomic rate would be 3.0 tons of wastewater biosolids per acre:

= (1.5 tons lime/acre)/(50% lime equivalent/ton)
= 3 tons/acre

In these calculations the calcium-carbonate equivalent (50%) and the agronomic rate of 3.0 tons are expressed on a dry weight basis.

In this same example, assume that the application rate to meet the nitrogen need of the crop was 3.7 tons/acre. The lower rate determines the agronomic rate. Although 3.7 tons/acre of wastewater biosolids are required to provide the nitrogen recommendation, that amount would raise soil pH above the desired range. The agronomic rate would be 3.0

tons/acre and the balance of the nitrogen recommendation would be supplied by an alternative fertilizer such as ammonium nitrate.

Case for Nitrogen. The agronomic rate based on nitrogen is determined from the Clemson Extension Service recommendation for nitrogen and the PAN content of the wastewater biosolids. The Clemson Extension Service recommendation for nitrogen is published in Lime and Fertilizer Recommendations Based on Soil-Test Results, Circular 476 and is provided with each soil test. In addition, nitrogen recommendations may be obtained from the local county Extension office, a Certified Crop Adviser, an agronomist, or the Department of Agronomy and Soils at Clemson University.

The inorganic nitrogen is readily available

Wastewater biosolids contain both organic and inorganic forms of nitrogen. While inorganic nitrogen is readily available to plants, organic nitrogen is made available as the wastewater biosolids are decomposed by soil microorganisms. PAN is estimated from the chemical analysis of the material using the concentration of organic nitrogen and the concentration of nitrogen in two inorganic forms, nitrate and ammonium. The organic nitrogen concentration is calculated by subtracting the concentration of ammonium from the total Kjeldahl nitrogen (TKN). TKN does not include nitrate unless specified.

It is assumed that the nitrogen in the nitrate form is PAN, but that one-half in the ammonium form is lost by volatilization if the wastewater biosolids are applied to the soil surface. If injected, it is assumed that no loss occurs through volatilization.

Only a portion of the organic nitrogen is PAN. Estimates of mineralization are used to calculate the contribution of organic nitrogen to PAN. The table below lists mineralizations used for several wastewater biosolids treatment processes:

Wastewater Biosolids Treatment Process	% Org-N Mineralized
Unstablized primary & waste-activated	40
Alkaline-stabilized	30
Aerobically digested	30
Anaerobically digested	20
Composted	10

Role of Soil Monitoring. Compared to commercial fertilizer, plant-available nitrogen in wastewater biosolids can be quite varied. Soil monitoring helps account for the variability of both plant-available nitrogen and mineralization rate.

Soil monitoring allows you to check the assumptions made when setting the application rate

Soil monitoring is a low-cost option for verifying that the application rate is at the agronomic rate. Many programs set application rates at 100% of the estimated agronomic rate. However, programs that apply wastewater biosolids to the same sites at more conservative rates (e.g., not greater than 50% based on an estimate of the agronomic rate) normally have a more limited soil monitoring program in place.

Soil monitoring plays a key role in setting the application rate when wastewater biosolids are proposed to be applied at the same site for a second time. Soil monitoring is a tool to determine program-specific estimates of the mineralization rate — since it was originally assumed. Since actual nitrogen content in wastewater biosolids can vary, soil monitoring provides an opportunity to determine if there is a buildup of nitrogen in the soil. This monitoring provides information useful in adjusting the application rate for subsequent applications, if appropriate.

The amount of plant-available nitrogen converted for various wastewater biosolids can vary from 5 to 80 percent or greater in one year. It is wise to use a conservative estimate of mineralization rate, a high rather than a low rate, initially and adjust the estimate as soil monitoring reflects that more or less nitrogen remains in subsequent years.

Monitoring should be intensive enough that the person in charge of land application either: **(1)** gains confidence that the initial estimates of agronomic rates were correct, or **(2)** can make adjustments in amount of application as necessary. As long as the nature of the wastewater biosolids does not change appreciably, monitoring can decrease with time. If mineralization rates other than the ones noted in the above table are used, incubation studies should be done to justify the alternate mineralization rates.

Monitoring should be intensive enough ... to be able to make adjustments in application rates

It is recommended that soil samples be taken in selected fields and analyzed for metals and nitrogen content before applications are made. This is suggested to help insure that background soil levels will pose no concerns later. Some soils in South Carolina, especially in the Piedmont, may contain appreciable amounts of arsenic and lead. Old cotton fields and orchards in particular are fields where higher than normal concentrations may be found. It is prudent to have data verifying the initial soil concentrations. Once wastewater biosolids are applied to a field, it may be difficult to prove that

elevated concentrations of a certain metal was not the direct result of applying wastewater biosolids.

Routine soil testing of surface soils (0-6 inches) before application of wastewater biosolids or fertilizer is recommended for all projects. Routine soil test results include soil pH and lime requirements, as well as nutrient information.

✏ Application Methods

The application method is an integral part of a management program. This choice is related to other important land application issues. Familiar methods include injection, surface spreading and spraying. Wastewater biosolids which are applied to the surface are often incorporated (e.g., discing) as a follow-up measure.

Selection of particular application options can serve to address regulatory concerns such as vector attraction. While surface spreading is a legitimate option, buffer areas usually need to be greater compared to buffers for injection or incorporation.

Injection, for example, can reduce the level of treatment required

Program managers may elect to meet regulatory directives by providing further treatment of wastewater biosolids at the treatment facility. Such an approach will often provide more flexibility in choosing land application methods. Injection or incorporation, for example, can reduce the level of treatment required.

The choice of application method may be subject to the type of crop grown. Injection is impractical for application to forest lands. Spraying is often the preferred choice for this type of site. Incorporation of dewatered wastewater biosolids via discing needs to be done at a time that does not affect crops. Careful evaluation of the types of sites and crops available will play an important part in selecting the application method or methods.

DHEC Approval Process

✏ Project Classification

Approval by DHEC is required for all land application programs and/or projects. In some cases, permits may be required by both the Bureaus of Solid and Hazardous Waste Management and Water Pollution Control. In most cases, a permit from Water Pollution Control is all that would be required. The following procedures do not account for unique permitting circumstances. Certain municipal and industrial projects will vary from this general procedure. For example, industries with wastestreams that do no contain pathogens may not need to treat for pathogens.

For the purpose of Water Pollution Control's permitting program, land application projects generally fall in one of two classifications: Group I and Group II. These classifications are primarily a function of the level of treatment provided.

Group I - Wastewater biosolids suitable for land application, including those meeting EPA's definition of Class B and Class A (though not meeting the Table 3 requirements for metals).

Group II - Wastewater biosolids treated such that they are suitable for distribution to lawns and as well as bulk application to farm land. Referred to as "exceptional quality" (EQ) wastewater biosolids. Meets EPA's Class A definition and meets the Table 3 requirements for metals (40 CFR 503).

GROUP I SUMMARY

Group I wastewater biosolids are suitable for land application since they have been treated to standards which provide for protection of public health and the environment. Group I wastewater biosolids include Class B and Class A material, as defined by the 503 regulations.

Class B. Considered the baseline standard (per 40 CFR 503) for land application, Class B wastewater biosolids meet certain requirements for metals, vector attraction reduction and pathogens. Site restrictions apply, as well.

METALS - The concentration of metals must not exceed the values in Table 1 of 40 CFR 503 and the cumulative loading rates (per site) identified in Table 2 of 40 CFR 503.

TABLE 1 (503.13)
CEILING CONCENTRATIONS

Pollutant	Level (mg/kg)
Arsenic	75
Cadmium	85
Copper	4,300
Lead	840
Mercury	57
Molybdenum	75
Nickel	420
Selenium	100
Zinc	7,500

TABLE 2 (503.13)
CUMULATIVE LOADING RATES

Pollutant	Rate	
	kg/ha	lb/ac
Arsenic	41	37
Cadmium	39	35
Copper	1,500	1,370
Lead	300	274
Mercury	17	15
Molybdenum	n/a	n/a
Nickel	420	383
Selenium	100	91
Zinc	2,800	2,550

VECTOR ATTRACTION REDUCTION - There are 10 options to meet the vector attraction reduction requirement. Options, which are detailed in 40 CFR 503.33, range from treatment processes to application approaches.

PATHOGENS - To meet Class B standards, treatment for pathogen reduction must be performed to meet one of three approaches detailed in 40 CFR 503.32:

- Meet a specific fecal coliform standard, or
- Use one of five PSRP treatment processes, or
- Use an alternative process approved by EPA.

SITE RESTRICTIONS - Eight restrictions apply, ranging from management of food crops to controlling public access. See 40 CFR 503.32 for a list of these restrictions.

Class A. Group I wastewater biosolids include those meeting Class A criteria (though they may be not meeting the standards for metals in Table 3) — i.e., not "EQ" wastewater biosolids. Wastewater biosolids meeting Class A standards have been treated to a higher degree as summarized below:

METALS - These requirements are the same as those indicated above for Class B.

VECTOR ATTRACTION REDUCTION - These requirements are the same as those indicated above for Class B.

PATHOGENS - The requirements for Class A are quite specific. See 40 CFR 503.32 for details. In general, they are more stringent than Class B. Either the fecal coliform or salmonella density must less than a specified amount. In addition, one of the following options must be selected:

Pathogen requirements for Class A are quite specific

- Application of one of four approaches, or
- Use of one of seven PFRP treatment processes, or
- Use an alternative process approved by EPA.

SITE RESTRICTIONS - Site restrictions generally are not warranted.

GROUP II SUMMARY

Group II wastewater biosolids, like Group I wastewater biosolids, are suitable for land application. They have been treated to even higher standards which provide for protection of public health and the environment. For DHEC permitting purposes, Group II is equivalent to the "EQ" description in the preamble of 40 CFR 503 (i.e., Class A material which also meets the more stringent metals levels in Table 3 of 40 CFR 503).

Group II wastewater biosolids are suitable to sell or give away in a distribution and marketing program because of the relatively low level of metals and pathogens as well as a high level of treatment to reduce vector attraction.

Since Group II ("EQ") has been treated to higher standards, there are minimal regulatory controls on its beneficial use. DHEC's program makes the following distinction: Wastewater biosolids distributed in bags or small containers have no responsibility for tracking of the material. Programs with bulk distribution will typically track the application rate and destination of the wastewater biosolids. The details of regulatory obligations will be identified in individual permits.

Group II is equivalent to "EQ" material, i.e., Class A which also meets the more stringent metals levels (Table 3)

While Group II wastewater biosolids meet EPA's highest standards for metals, pathogens and vector attraction reduction, wastewater biosolids should still be applied at agronomic rates. This includes addressing either the nitrogen-based or calcium-carbonate equivalent application rate. Therefore, for bulk application of Group II wastewater biosolids, DHEC expects facility owners to be responsible that wastewater biosolids are applied at agronomic rates. The following describes some Group II requirements distinct from Group I:

METALS - Table 1 requirements must be met. In addition, average concentrations must be documented to meet Table 3, below. Refer to 40 CFR 503.13 for further information.

TABLE 3 (503.13)
AVERAGE CONCENTRATIONS

Pollutant	Level (mg/kg)
Arsenic	41
Cadmium	39
Copper	1,500
Lead	300
Mercury	17
Molybdenum	n/a
Nickel	420
Selenium	36
Zinc	2,800

VECTOR ATTRACTION REDUCTION - There are 8 options to meet the vector attraction reduction requirement. Options are detailed in 40 CFR 503.33.

PATHOGEN REDUCTION - Same as Class A.

LABELLING - A label or sheet should include the following:

Labelling Information

- Name, address, and phone number of the wastewater biosolids preparer.
- Most recent nutrient and metals analyses. Calcium-carbonate equivalence for alkaline-stabilized wastewater biosolids.
- Suggested application rates which do not cause agronomic rates for common uses to be exceeded.
- If the calcium-carbonate equivalency exceeds 25%, include a statement that expresses that the wastewater biosolids should be evaluated as a liming material.
- A statement that land application of this material is prohibited except in accordance with the label/information sheet.

ELEMENTS OF A GROUP I SUBMITTAL

Below is a summary of elements common for a request for approval of a land application project/program. For more details, contact DHEC's wastewater permitting program.

Facility Information. Information on the wastewater treatment operation, including location information and permit number should be included.

Wastewater Biosolids Characterization. Perhaps the most critical aspect of a project submittal is the wastewater biosolids characterization. Several aspects of the wastewater biosolids must be addressed.

- NON-HAZARDOUS NATURE - Wastewater biosolids must be shown to be non-hazardous. Typically, this demonstration centers around performing a toxicity characteristic leaching procedure (TCLP) test for metals and organics. However, other documentation may be acceptable (e.g., certification that TCLP for organics has not changed), as determined on a case-by-case basis.

- NUTRIENTS - To determine the agronomic rate and the rate of supplemental commercial fertilizer, data should be submitted on:

  - Total Nitrogen
  - Organic Nitrogen
  - Ammonium Nitrogen
  - Nitrate Nitrogen
  - Total Phosphorus
  - Total Potassium

- ALKALINITY - Alkalinity or calcium-carbonate equivalent must be determined on alkaline-stabilized wastewater biosolids. This may be the rate-limiting factor, depending on soil pH and the requirement for lime.

The calcium-carbonate equivalent ... may be the rate-limiting factor.

- POLLUTANTS - A representative analysis (Appendix B identifies documents to assist in how to take a representative sample) for the following inorganic pollutants should be performed on a dry weight basis on the wastewater biosolids:

  - Arsenic
  - Cadmium
  - Copper
  - Lead
  - Mercury
  - Molybdenum
  - Nickel
  - Selenium
  - Zinc

- PATHOGENS & VECTORS - Information about pathogen reduction and vector attraction reduction should be included. The applicant should describe which options were selected to meet pathogen and vector requirements. Since some industrial wastewater biosolids contain no sanitary wastewater, pathogen requirements may not apply. The following may be required, depending on whether the wastewater biosolids are Class A or Class B, as well as the particular method to achieve pathogen and vector attraction reduction (See 40 CFR 503.32 & 503.33 for more information):

  - Salmonella sp. bacteria
  - Specific oxygen uptake rate
  - Total, fixed, volatile solids
  - Fecal coliform
  - Helminth ova
  - Enteric viruses

Transportation & Application. Include a description of the proposed wastewater biosolids transportation and application plan. If a contract hauler and/or applier will be used, a copy of the contract should be provided.

Site(s) Characterization. Proposed application site(s) must be characterized. Maps should be submitted which show area topography as well as other site characteristics (open surface water, wells, houses, roads, etc.).

Issues to be considered while selecting an application site should involve the quantity of wastewater biosolids for disposal/use, the proximity of the proposed site to the treatment plant, year-round site accessibility, and the site's proximity to residential areas (for nuisance concerns). The property owner's

approval and related agreements concerning the application of wastewater biosolids should also be submitted.

Site Selection. Fields selected for land application of wastewater biosolids should be capable of normal agricultural production. Fields on which reasonable yields of row crops or forages have been obtained for several years are normally quite suitable for application.

Generally, fields growing crops effectively will be good sites for wastewater biosolids

It is assumed that wastewater biosolids can be applied to most fields where a crop is grown. However, a higher level of management and monitoring will be required on some sites than others. Details will be covered in the Site Monitoring section. As to site selection, a project submittal would include:

- Soil map delineating fields
- Information on site slopes
- Site suitability certification (sample in Appendix E)

The site suitability certification will reduce the need to submit detailed site information to DHEC.

Setbacks. Information should be provided showing buffer areas. Recommended setbacks (linear feet), which might vary depending on specific circumstances, are listed below:

Site Description	Application Method		
	Injection/ Incorporation	Surface	Irrigation
Property Boundary[1]	25	50	100
Public or Private Road[2]	25	50	100
Development (residential)	50	100	500
Inhabited Dwelling	50	100	500
Potable Wells	100	100	100
Drainage ways	50	50	100
Surface Waters	50	100	200

Note 1: *Not applicable if adjacent property owner agrees in writing.*

Note 2: *A road not owned by landowner receiving wastewater biosolids*

Crop Management Plan. It is important to develop a plan for beneficial use of wastewater biosolids. A submittal should describe crops to be grown, proposed application rates/schedule and harvesting plans. The crop management plan should be certified as indicated in Appendix E to expedite DHEC review.

Monitoring Plan. The submittal should address monitoring of wastewater biosolids, soil and ground water, as appropriate. Details on monitoring requirements are found in a later section.

Site Restriction Plan. A description of controlling access and meeting the other applicable site restrictions for Class B projects should be included. Letters or agreements with property owners agreeing to comply with site restrictions should be provided.

✏ Elements of a Group II Submittal

Many of the components of a Group II submittal parallel the Group I submittal. For more details, contact DHEC's wastewater permitting program. The Group II submittal is distinct in the following ways:

- Application site information is limited. For distribution in small quantities, tracking will not be required. Notification of bulk application will be made prior to application.
- Certification of site suitability and crop management is not necessary.
- Distribution and marketing information should be detailed, including labelling proposal.
- Site restriction and setback information is not applicable since the material has been treated to high levels.
- All facility and sludge characterization information should be submitted in similar fashion as Group I.

✏ Permitting Process

Since programs will be evaluated individually, the permitting process may vary. Modifications to add sites typically require limited information. However, the process described below generally applies. The permitting process is different for Group I and Group II projects. Since Group II wastewater biosolids are treated to higher standards, the permitting process is simplified.

In most cases, wastewater biosolids permitting involves modification of the generator's effluent discharge permit (i.e., NPDES or Land Application permit). In some cases, DHEC may issue a land application permit exclusively for the use/disposal of wastewater biosolids. Permit changes regarding application

of wastewater biosolids must be consistent with the County's Solid Waste Plan.

Public Input. Permits modifications typically involve placing the modified permit on public notice for 30 days. If significant comments are received during the comment period, or if other circumstance warrant, DHEC will hold a public hearing on the proposed permit modification. Notice of a public hearing must precede the hearing by 30 days.

Comments received during the comment period or at the hearing are fully evaluated prior to DHEC reviewers making a final permit decision. Final permit decisions can be appealed in accordance with DHEC's regulation on contested cases and procedures of the State's Administrative Law Judge Division.

The general public notice differences are noted below:

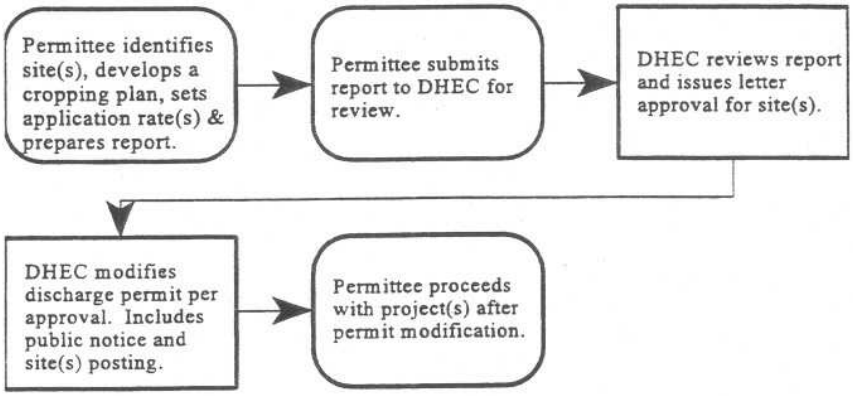
GROUP I -	Individual sites or groups of sites are approved. Following each approval, permits are modified and placed on public notice.
GROUP II -	Overall programs are normally approved for a 5-year period, following a one-time public notice.

Backup Disposal Options. An important part of a wastewater biosolids management program is a contingency plan. Most facility owners accomplish this through approval to landfill wastewater biosolids — even if the landfill is in a different county. Going through the process of getting approval for landfilling provides assurance that if problems occur in the land application program, an alternative exists. While landfilling may be more expensive, having landfilling approved in the permit provides flexibility.

Having landfilling approved in the permit provides flexibility

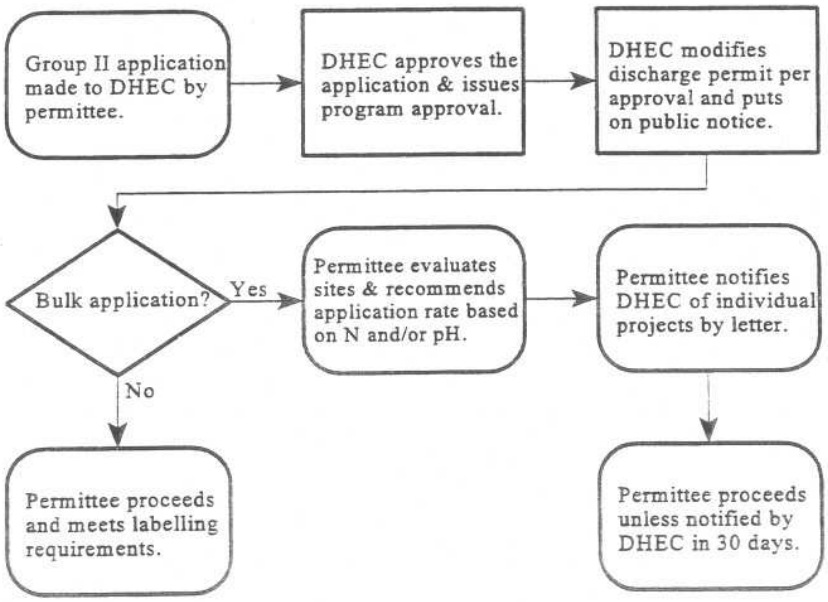
Often, effluent discharge permits address this "backup" option in the permit. In that way, switching to landfilling during the life of the permit does not require DHEC approval at the time of change — providing maximum flexibility for a wastewater facility. Facility owners need to identify they have the ability to beneficially use and/or landfill wastewater biosolids throughout the life of the permit, taking into account the design capacity of the facility.

Group I Permitting Process. In this process, the effluent discharge permit (e.g., NPDES) is modified each time a site or group of sites is approved for land application. It is helpful to seek the maximum number of site approvals at a given time to minimize the number of permit modification process delays.



When permits are issued, delays could occur if the permit decision is appealed. In such cases, an adjudicatory hearing may be required.

Group II Permitting Process. Group II ("EQ") wastewater biosolids production can result in a more timely permitting process. See below:



In the Group II process, the permittee puts together a program for wastewater biosolids use and/or disposal for the life of the permit (sites suitable for five years of wastewater biosolids production). Instead of getting sites approved — sites that offer adequate acreage to meet the need of the treatment facility for the permit life — most permittees obtain approval to landfill as discussed above.

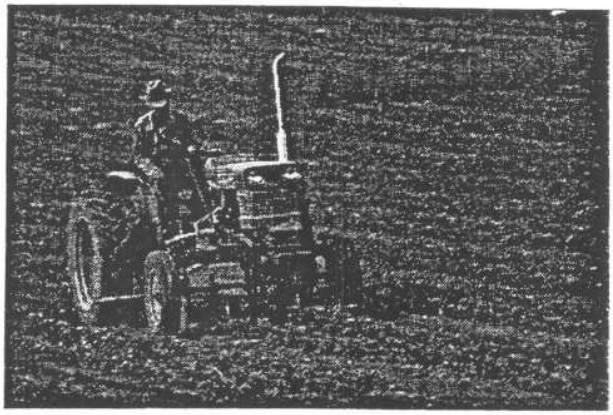
When permits are issued, delays could occur if the permit decision is appealed. In such cases, an adjudicatory hearing may be required.

Deriving Material. If a person derives a material from wastewater biosolids, a permit is required for such an operation. The exception to this is when the deriver receives wastewater biosolids that are classified as Group II because of the high level of treatment provides. In such cases, if the person generating the Group II material has a permit with DHEC addressing the treatment processes (to insure that the material meets Group II criteria), then the deriver would not need a DHEC permit for the treatment process and use of the derived material. However, certain application requirements (e.g., agronomic rate) would apply.

Operational Responsibilities

✏ Application of Wastewater Biosolids

Careful planning concludes with the application process itself. From a public relations view, this is the most important part of a program. Proper communication with land owners and community leaders can be helpful to insure a successful program.



Application is coordinated with farming operations

Typically, state permit conditions require the following:

- Operate transportation equipment to prevent spills and leaks.
- Avoid nuisance and odor problems.
- Keep records of the timing, quantity and location of the application.
- Comply with site restrictions for Class B wastewater biosolids.
- Insure that materials needing to be incorporated into the soil are done so in the proper time.
- Maintain buffer zones, as applicable.

While not typically required by state permits, other recommendations include:

- Have all your trucks clearly marked with a name and phone contact for good public relations.
- Stay in close contact with contract haulers and appliers, since the permittee retains responsibility for the project.
- Flag buffer zones.
- Notify DHEC's District Office of activities.
- Remind land owners of site restrictions, if any.
- Use calibrated equipment to land apply.

✏ Monitoring

Soil Monitoring. Soil monitoring is a valuable tool to determine if assumptions about prior application of wastewater biosolids are accurate. Generally, the more conservative the approach in setting the application rate, the less restrictive the monitoring requirements. Soil samples should be taken on a

field basis. A "field" is an area of land where a single crop is grown or is in a particular crop rotation. Field size should be based on soil conditions and crops grown. For example, an area with a portion in corn and a portion in hay should be considered two fields.

The more conservative the application rate, the less restrictive the soil monitoring responsibilities

Soil monitoring is needed when sites receive multiple applications of wastewater biosolids. For bulk alkaline-stabilized wastewater biosolids, soil pH is necessary to determine the appropriate application rate in all cases. General guidelines are as follows:

- Soil nutrient monitoring is not necessary for alkaline-stabilized wastewater biosolids if the nitrogen loading is less than 50 lbs/yr. However, pH sampling is necessary to verify soil pH being maintained in appropriate ranges.
- If a metal is a limiting pollutant, representative samples should be obtained from the top six inches of soil and the data evaluated prior to subsequent applications.
- In cases where cumulative loading rate reaches 80% of the maximum, soil monitoring for that metal should be performed to evaluate if subsequent applications are appropriate.
- If tests indicate mineral nitrogen (ammonium + nitrate) is greater than 200 lbs/acre (through the 4-foot depth), application rates should be reduced from previous estimates. If the level exceeds 200 lbs/acre for multiple years, applications should cease.
- Soil monitoring for nitrogen is not necessary for one-time application of wastewater biosolids or for one application every four years.

Monitoring is not needed for one-time applications

While Group II projects are normally determined on a case-by-case permit decision, typical Group I guidelines would include:

- Soil samples for nitrogen should be taken through the four-foot depth in the following increments: 0-6, 6-12, 12-24, 24-36 and 36-48 inches.
- Soil monitoring for nitrogen is necessary prior to a second application (or third, etc.).
- Normally, soil monitoring for nitrogen shall be done on 50% of the fields prior to application. For sites where the application rate is ≤50% of the agronomic rate (or for example, 100% every other year), one representative field can be sampled for nitrogen since a more conservative application rate was selected.

A summary of these guidelines for monitoring nitrogen is show as follows:

Nitrogen Monitoring Summary			
Percent of Agronomic Rate	Frequency of Application	Monitoring Frequency	Number of Fields
51-100%	Annual	Annual	50%
≤50%	Annual	Annual	1/farm
≤50%	Biennial/Tri-ennial	Biennial/Tri-ennial	1/farm
0-100%	Every 4th year	None	None

For some projects (e.g., for generator-owned sites, certain industrial projects) additional monitoring may be warranted, including ground water monitoring.

Wastewater Biosolids. To determine the amount of wastewater biosolids to apply per acre of land, reliable estimates are needed of the composition of the wastewater biosolids. The following table gives the typical monitoring frequency required based on the amount of wastewater biosolids (dry weight) applied, sold or given away (Note: this table differs from the federal 503 regulations, Table 1 of 503.16). This table applies to metals analyses, pathogen and vector attraction reduction confirmation (if applicable), and the rate-limiting nutrient (e.g. nitrogen). DHEC may require more frequent monitoring if the wastewater biosolids constituents vary significantly over time, as determined on a case-by-case basis.

AMOUNT "A" OF WASTEWATER BIOSOLIDS LAND APPLIED		MONITORING FREQUENCY[1,2]
Metric tons/year	**Tons/year**	
A < 1,500	A < 1,653	Once per quarter (4 times/year)
1,500 ≤ A < 15,000	1,653 ≤ A < 16,537	Once per 60 days (6 times/year)
A ≥ 15,000	A ≥ 16,537	Once per month (12 times/year)

Note 1: *Batch processes may require different measurement frequencies.*

Note 2: *Initial frequency until variability is established [see 40 CFR 503.16(a)(2)].*

Sampling and analyses should be done frequently enough to document a reliable estimate of rate-limiting components of the waste material. It is recommended that before land application commences, two or more analyses be performed to define the concentration ranges for those chemical or biological components that limit the quantity that can be applied. The potential rate-limiting constituents should be analyzed frequently during the initial stages of land application to determine variability. After wastewater biosolids have been monitored for two years and consistency is determined, the frequency of monitoring may be increased or decreased depending upon the variability of the wastewater biosolids constituents — subject to current regulatory boundaries.

Prior to application, it is recommended to focus on the rate-limiting constituents

Nitrogen can also be one of the most variable chemical components. Application of nitrogen at agronomic rates can be accomplished only when the nitrogen composition is known with a reasonable degree of certainty. If nitrogen, or any limiting constituent, varies with the time of the year (winter, summer, etc.), variability over time should be documented. With alkaline-stabilized wastewater biosolids, variability of calcium-carbonate equivalent over time should also be documented.

✏ Recordkeeping & Reporting

The permittee is ultimately responsible for all reporting and recordkeeping requirements contained in the project approval. Wastewater biosolids characterization information should be submitted according to the amount of wastewater biosolids land-applied each year. If a contractor is used for the further preparing, land application, and/or distribution and marketing of the wastewater biosolids, provisions should be made for the appropriate party to report to DHEC. A yearly followup report is required to address overall project status.

Laboratories. All laboratory work done because of a permit requirement must be performed by a DHEC-certified laboratory. This requirement is not unique to a wastewater biosolids land application program.

✏ Site Restrictions

Site restrictions generally only apply to wastewater biosolids identified as Class B. Details of these site restrictions are found in 40 CFR 503.32. In summary, the restrictions include time intervals during which:

- Food, feed, turf, and fiber crops may not be harvested.
- Animals are not allowed to graze.
- The public must be denied access.

The time restriction for the above activities ranges from 30 days to a year after application of wastewater biosolids. See regulations for details.

Appendices

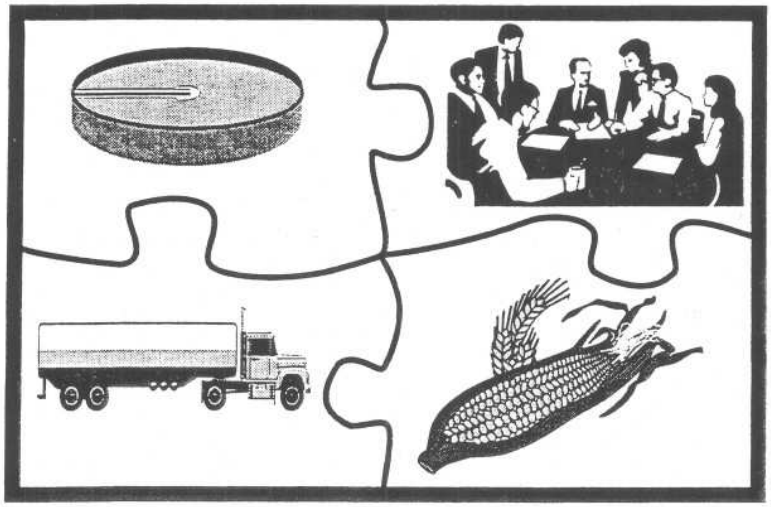
A. DEFINITIONS

B. TECHNICAL ASSISTANCE OPTIONS

C. SAMPLE PLANT-AVAILABLE NITROGEN CALCULATIONS

D. SAMPLE APPLICATION RATE CALCULATIONS

E. SAMPLE CERTIFICATION FORMS



Beneficial use is not always puzzling

Appendix A: Definitions

Note: These definitions are not intended to substitute for any regulatory or statutory definitions.

AEROBIC DIGESTION is the biochemical decomposition of organic matter in wastewater biosolids into carbon dioxide and water by microorganisms in the presence of air.

AGRICULTURAL LAND is land used as pasture and land on which a food crop, a feed crop, or a fiber crop is grown.

AGRONOMIC RATE is the whole wastewater biosolids application rate (dry weight basis) designed to:
(1) provide the amount of nitrogen needed by the food crop, feed crop, fiber crop, cover crop, or vegetation grown on the land and minimize the amount of nitrogen in the wastewater biosolids that passes below the root zone of the crop or vegetation grown on the land to the ground water, and (3) provide the amount of other organic an inorganic plant nutrients which promote crop or vegetative growth, such as calcium-carbonate equivalency .

ANAEROBIC DIGESTION is the biochemical decomposition of organic matter in wastewater biosolids into methane gas and carbon dioxide by microorganisms in the absence of air.

ANNUAL WHOLE "SLUDGE" APPLICATION RATE is the maximum amount of wastewater biosolids (dry weight basis) that can be applied to a unit area of land during a 365 day period.

BULK "SLUDGE" is wastewater biosolids that are not sold or given away in a bag or other container for application to the land.

COVER CROP is a small grain crop, such as oats, wheat, or barley; grasses, or other crop grown for agronomic use.

DENSITY OF MICROORGANISMS is the number of microorganisms per unit mass of total solids (dry weight) in the wastewater biosolids.

DRY WEIGHT BASIS means calculated on the basis of having been dried at 105 degrees Celsius until reaching a constant mass (i.e., essentially 100 percent solids content).

FEED CROPS are crops produced primarily for consumption by animals.

FIBER CROPS are crops such as flax and cotton.

FOOD CROPS are crops consumed by humans. These include, but are not limited to, fruits, vegetables, and tobacco.

FOREST is a tract of land thick with trees and underbrush.

GROUND WATER is water below the land surface in the saturated zone.

LAND APPLICATION is the spraying or spreading of wastewater biosolids onto the land surface; the injection of wastewater biosolids below the land surface; or the incorporation of wastewater biosolids into the soil so that wastewater biosolids can either condition the soil or fertilize crops or vegetation grown in the soil.

LAND WITH A HIGH POTENTIAL FOR PUBLIC EXPOSURE is land that the public uses frequently. This includes, but is not limited to, a public contact site and a reclamation site located in a populated area (e.g., a construction site located in a city).

LAND WITH A LOW POTENTIAL FOR PUBLIC EXPOSURE is land that the public uses infrequently. This includes, but is not limited to, agricultural land, forest, and a reclamation site located in an unpopulated area (e.g., a strip mine located in a rural area).

MONTHLY AVERAGE is the arithmetic mean of all measurements taken during the month.

OTHER CONTAINER is either an open or closed receptacle. This includes, but is not limited to, a bucket, a box, a carton, and a vehicle or trailer with a load capacity of one metric ton or less.

PASTURE is land on which animals feed directly on feed crops such as legumes, grasses, grain stubble, or stover.

PATHOGENIC ORGANISMS are disease-causing organisms. These include, but are not limited to, certain bacteria, protozoa, viruses, and viable helminth ova.

PERSON WHO PREPARES "SLUDGE" is either the person who generates wastewater biosolids during the treatment of domestic sewage in a treatment works or the person who derives a material from wastewater biosolids.

PH means the logarithm of the reciprocal of the hydrogen ion concentration.

PUBLIC CONTACT SITE is land with a high potential for contact by the public. This includes, but is not limited to, public parks, ball fields, cemeteries, plant nurseries, turf farms, and golf courses.

RECLAMATION SITE is drastically disturbed land that is reclaimed using sewage wastewater biosolids. This includes, but is not limited to, strip mines and construction sites.

SPECIFIC OXYGEN UPTAKE RATE (SOUR) is the mass of oxygen consumed per unit time per unit mass of total solids (dry weight basis) in the wastewater biosolids.

TOTAL SOLIDS are the materials in wastewater biosolids that remain as residue when wastewater biosolids are dried at 103 to 105 degrees Celsius.

TREAT OR TREATMENT OF "SLUDGE" is the preparation of sludge (wastewater biosolids) for final use or disposal. This includes, but is not limited to, thickening, stabilization, and dewatering. This does not include storage of wastewater biosolids.

UNSTABILIZED SOLIDS are organic materials in wastewater biosolids that have not been treated in either an aerobic or anaerobic treatment process to include extended aeration or other treatment process approved by the Department.

VECTOR ATTRACTION is the characteristic of wastewater biosolids that attracts rodents, flies, mosquitos, or other organisms capable of transporting infectious agents.

VOLATILE SOLIDS is the amount of the total solids in wastewater biosolids lost when wastewater biosolids are combusted at 550 degrees Celsius in the presence of excess air.

Appendix B: Technical Assistance Options

Clemson Extension Service

USDA Natural Resources Conservation Service (formerly SCS)

Water Environment Federation

S.C. Water & Pollution Control Association

Publication Listing

✏ *A Plain English Guide to the EPA Part 503 Biosolids Rule*, September 1994 [Available from the OW Resource Center, ERIC, NTIS]

✏ *Questions and Answers on Part 503* [Available in late 1994 from the OW Resource Center]

✏ *Preparing Sewage Sludge For Land Application or Surface Disposal: A Guide for Preparers of Sewage Sludge on the Monitoring, Recordkeeping, and Notification Requirements of the Federal Standards for the Use or Disposal of Sewage Sludge, 40 CFR 503*, August 1993 [Available from the OW Resource Center, the National Small Flows Clearinghouse (NSFC), National Technical Information Service (NTIS)]

✏ Land Application of Sewage Sludge: A Guide for Land Appliers on the Recordkeeping and Notification Requirements of the Federal Standards for the Use or Disposal of Sewage Sludge, 40 CFR 503, [Available from OW Resource Center]

✏ *Domestic Septage Regulatory Guidance: A Guide to the EPA 503 Rule*, Sept. 1993 [Available from OW Resource Center, NSFC, NTIS, Education Resources Information Center (ERIC)]

✏ *A Guide to the Biosolids Risk Assessment Methodology for the EPA 503 Rule* [Available in 1995 from OW Resource Center]

✏ *The Summary for Part 503*, by EPA's Bob Bastian [Document is part of the 39-page info package on sources of sludge available through NSFC (WWPCGN50). Summary is also available from the OW Resource Center]

✏ *POTW Sludge Sampling and Analysis Guidance Document*, August 1989 [1989 document available from NSFC & NTIS (#PB93-227957); limited availability from OWRC; under revision; new version in 1995]

✏ *EPA'S Policy Promoting the Beneficial Use of Sewage Sludge/The New Proposed Technical Sludge Regulations*, June 1989 [Available from OWRC, NTIS; renamed: Biosolids Recycling: Beneficial Technology for a Better Environment]

✏ *Biosolids Recycling: Beneficial Technology for a Better Environment*, June 1994 [Available from OWRC, ERIC, NTIS]

✏ *EPA'S Sewage Sludge Use and Disposal Documents List*, (English and Spanish versions available),
Updated October 1994 [Available from NSFC (part of the 39-page package), and the OWRC]

✏ *Environmental Regulations and Technology: Control of Pathogens and Vector Attraction in Sewage Sludge* (EPA/625/R-92/013) [Available from CERI Publications Office, Cincinnati, Ohio]

✏ *Process Design Manual for Land Application of Sewage Sludge and Domestic Septage* (Old Name: Land Application of Municipal Sludge) [Old version available from CERI Publications Office; document is under revision by CERI: available July 1995]

✏ USEPA OW/Office of Science & Technology's Technical Support Documents for Part 503 [Available only from NTIS]

PUBLICATION SOURCES (Call for Prices/Availability)

- ➡ Office of Water Resource Center (202) 260-7786
- ➡ Education Resources Information Center (614) 292-6717
- ➡ National Small Flows Clearinghouse 1-800-624-8301
- ➡ National Technical Information Service (703) 487-4650
- ➡ CERI Publications Office (513) 569-7562
- ➡ CERI/ORD Electronic Bulletin Board (24 hours) (513) 569-7610
(Sludge/Biosolids/Residuals: Use Conference 11)

Appendix C: Sample Plant-Available Nitrogen (PAN) Calculations

$PAN = NO_3\text{-}N + K_{vol} (NH_4\text{-}N) + K_{min}(Org.\ N)$

$PAN = NO_3\text{-}N + K_{vol} (NH_4\text{-}N) + K_{min} [TKN - NH_3\text{-}N)]$

Where:

NO_3-N = Concentration of nitrate N in biosolids.

NH_3-N = Concentration of ammonium N in biosolids.

TKN = Total Kjeldahl Nitrogen in biosolids.

Organic N = Concentration of organic N in biosolids.

Org. N = Total N - Inorg. N

Org. N = TKN - NH_3-N

K_{vol} = Volatilization factor, or fraction of NH_3-N lost by volatilization.

VOLATILIZATION FACTORS

Application Methods	Volatilization Factor
Surface spreading	0.50
Surface spreading + incorporation	0.75
Sub-surface injection	1.00

K_{min} = Mineralization factor, or fraction of organic N converted to PAN.

MINERALIZATION FACTORS

WASTEWATER BIOSOLIDS TREATMENT PROCESS	% ORG-N MINERALIZED
Unstablized primary & waste-activated	40
Alkaline-stabilized	30
Aerobically digested	30
Anerobically digested	20
Composted	10

Given the following information determine the PAN content of the wastewater biosolids:

Aerobically digested wastewater biosolids are to be surface spread and immediately incorporated by discing. Calculate the plant available nitrogen for the wastewater biosolids given the following information:

Parameter	%	ppm (% x 10,000)	lbs/dry ton (ppm x 0.002)
TKN	5.75	57,500	115
NH_3-N	0.80	8,000	16
NO_3-N	0.50	5,000	10

$PAN = NO_3\text{-}N + K_{vol} (NH_3\text{-}N) + K_{min}[(TKN) - (NO_3\text{-}N + NH_3\text{-}N)]$

$PAN = 10 + 0.75(16) + 0.30\ [115 - (10 + 15)]$

$PAN = 10 + 12 + 0.30\ (90)$

$PAN = 10 + 12 + 27$

PAN = 49 lbs/dry ton

So, if the chosen crop had a nitrogen requirement of 150 lbs/acre/year:

Biosolids applied yearly = (Crop nitrogen needs)/(PAN content of the biosolids)

Biosolids applied yearly = (150 lbs/acre/year)/(49 lbs/dry ton)

Biosolids applied yearly = 3.06 dry tons/acre/year

Appendix D: Sample Application Rate Calculations

NITROGEN-BASED APPLICATION RATE
INFINITE SITE LIFE: MEETS TABLE 3

A. Background Information:

1. Treatment Level: Aerobically-Digested / Class B
2. Metal Concentration Level: Meets Monthly Levels from Table 3 of §503.13
3. Constituent Concentrations: See Attached Tables.
4. Project Type: Type I, Application to Farm Land
5. Crop(s) name: Fescue

B. Complete the following calculations using total concentrations:

Parameter	Table 3 Avg. Concentrations (mg/kg)	Residual Analysis (mg/kg)	x 0.002	= lbs/dry ton
Arsenic	41	1.75	x 0.002	= 0.0035
Cadmium	39	4.00	x 0.002	= 0.0080
Copper	1,500	1010.00	x 0.002	= 2.0200
Lead	300	42.70	x 0.002	= 0.0854
Mercury	17	2.05	x 0.002	= 0.0041
Molybdenum	75	8.00	x 0.002	= 0.0160
Nickel	420	15.65	x 0.002	= 0.0313
Selenium	100	4.32	x 0.002	= 0.0086
Zinc	2,800	1160.00	x 0.002	= 2.3200
Ammonia-N	N/A	6500	x 0.002	= 13.000
Calcium	N/A	10200	x 0.002	= 20.400
Magnesium	N/A	2900	x 0.002	= 5.8000
NO_3-NO_2-N	N/A	4300	x 0.002	= 8.6000
Phosphorus	N/A	22100	x 0.002	= 44.200
Potassium	N/A	3600	x 0.002	= 7.2000
Sodium	N/A	1050	x 0.002	= 2.1000
TKN	N/A	61000	x 0.002	= 122.00

C. **Plant Available Nitrogen (PAN) calculations and land application area requirements:**

CONSTITUENTS	Mg/Kg - DRY WEIGHT
TKN	61000
AMMONIA-N	6500
NO_3-NO_2-N	4300

1. Mineralization Rate (MR) = 30 %

   (These values can be established for the specific residual or default values can be used for domestic wastewater treatment residuals. The default values are as follows):

Unstabilized Primary, Secondary, and Waste-Activated Residuals	40%
Alkaline-Stabilized and Aerobically Digested Residuals	30%
Anaerobically Digested Residuals	20%
Composted Residuals	10%

2. Complete the following calculations for the application method proposed (please note, the Mineralization Rate (MR) should be used in the following as a decimal):

   PAN for Surface Application

   PAN = ((MR) x (TKN - NH_3)) + (0.5 x NH_3-N) + (NO_3-NO_2-N)

   PAN = (.30 x (61000 - 6500)) + (0.5 x 6500) + (4300)

   PAN = 23900 PPM Dry Weight

3. Total PAN to be land applied per year

   Total dry tons of residual to be land applied per year: 1500

   Total PAN in pounds per dry ton = $\frac{\text{(PAN in mg/kg Dry Weight) x 2000 Pounds/Ton}}{1{,}000{,}000}$

   = (PAN in PPM Dry Weight) x 0.002

   = 48 Pounds/Dry Tons

4. Crop information on nitrogen uptake per year

CROP(S)	ADVISED PAN VALUES (lbs/ac/yr)	PROJECT PAN VALUES (lbs/ac/yr)	CROP(S)	ADVISED PAN VALUES (lbs/ac/yr)	PROJECT PAN VALUES (lb/ac/yr)
Alfalfa	200		Forest	75	
Bermuda Grass	220		Milo	100	
Blue Grass	120		Small Grain	100	
Corn (Grain)	160		Sorghum (Silage)	180	
Corn (Silage)	200		Soybeans	150	
Cotton	70		Timothy, Orchard and Rye Grass	160	
Fescue	160	160			

Please provide the crop name and uptake rate if the specific crop is not listed above or provide the basis for the uptake rates used if different than the advised rates:

NONE

5. Nitrogen Based Residuals Application Rate = $\frac{\text{Crop Uptake Rate (lbs. PAN/acre/year)}}{\text{PAN in Residual (lbs./dry ton)}}$

Nitrogen Based Residuals Application Rate = $\frac{160.0 \text{ (lbs. PAN/acre/year)}}{48.0 \text{ (lbs./dry ton)}}$

Nitrogen Based Residuals Application Rate = 3.30 dry tons/acre/year

☞ **Site Life is Unlimited because residual meets §503.13 Table 3 limits.**

NITROGEN-BASED APPLICATION RATE
FINITE SITE LIFE: DOES NOT MEET TABLE 3

A. Background Information:

1. Treatment Level: Aerobically-Digested / Class B
2. Metal Concentration Level: Meets Ceiling Levels from Table 1 of §503.13 ONLY
4. Constituent Concentrations: See Attached Tables.
5. Project Type: Type I, Application to Farm Land
6. Crop(s) name: Bermuda Grass

B. Complete the following calculations using total concentrations:

Parameter	Table 1 Ceiling Levels (mg/kg)	Residual Analysis (mg/kg)	x 0.002	= lbs. / dry ton
Arsenic	75	1.75	x 0.002	= 0.0035
Cadmium	85	4.00	x 0.002	= 0.0080
Copper	4300	3500.00	x 0.002	= 7.0000
Lead	840	720.00	x 0.002	= 1.4400
Mercury	57	2.05	x 0.002	= 0.0041
Molybdenum	75	8.00	x 0.002	= 0.0160
Nickel	420	15.65	x 0.002	= 0.0313
Selenium	100	4.32	x 0.002	= 0.0086
Zinc	7500	1160.00	x 0.002	= 2.3200
Ammonia-N	N/A	6500	x 0.002	= 13.000
Calcium	N/A	10200	x 0.002	= 20.400
Magnesium	N/A	2900	x 0.002	= 5.8000
NO_3-NO_2-N	N/A	4300	x 0.002	= 8.6000
Phosphorus	N/A	22100	x 0.002	= 44.200
Potassium	N/A	3600	x 0.002	= 7.2000
Sodium	N/A	1050	x 0.002	= 2.1000
TKN	N/A	20000	x 0.002	= 40.00

C. Plant Available Nitrogen (PAN) calculations and land application area requirements:

CONSTITUENTS	Mg/Kg - DRY WEIGHT
TKN	20000
AMMONIA-N	6500
NO_3-NO_2-N	4300

1. Mineralization Rate (MR) = 30 %

   (These values can be established for the specific residual or default values can be used for domestic wastewater treatment residuals. The default values are as follows):

Unstabilized Primary, Secondary, and Waste-Activated Residuals	40%
Alkaline-Stabilized and Aerobically Digested Residuals	30%
Anaerobically Digested Residuals	20%
Composted Residuals	10%

2. Complete the following calculations for the application method proposed (please note, the Mineralization Rate (MR) should be used in the following as a decimal):

PAN for Surface Application

$PAN = ((MR) \times (TKN - NH_3)) + (0.5 \times NH_3\text{-}N) + (NO_3\text{-}NO_2\text{-}N)$

PAN = (.30 x (20000 - 6500)) + (0.5 x 6500) + (4300)

PAN = 11600 PPM Dry Weight

3. Total PAN to be land applied per year

Total PAN in pounds per dry ton = $\frac{\text{(PAN in mg/kg Dry Weight) x 2000 Pounds/Ton}}{1{,}000{,}000}$

= (PAN in PPM Dry Weight) x 0.002

= 23.2 Pounds/Dry Tons

4. Crop information on nitrogen uptake per year

CROP(S)	ADVISED PAN VALUES (lbs/ac/yr)	PROJECT PAN VALUES (lbs/ac/yr)	CROP(S)	ADVISED PAN VALUES (lbs/ac/yr)	PROJECT PAN VALUES (lb/ac/yr)
Alfalfa	200		Forest	75	
Bermuda Grass	220	220	Milo	100	
Blue Grass	120		Small Grain	100	
Corn (Grain)	160		Sorghum (Silage)	180	
Corn (Silage)	200		Soybeans	150	
Cotton	70		Timothy, Orchard and Rye Grass	160	
Fescue	160				

Please provide the crop name and uptake rate if the specific crop is not listed above or provide the basis for the uptake rates used if different than the advised rates:

NONE

5. Nitrogen Based Residuals Application Rate = $\frac{\text{Crop Uptake Rate (lbs. PAN/acre/year)}}{\text{PAN in Residual (lbs./dry ton)}}$

Nitrogen Based Residuals Application Rate = $\frac{220 \text{ lbs. PAN/acre/year}}{23.2 \text{ lbs./dry ton}}$

Nitrogen Based Residuals Application Rate = 9.5 dry tons/acre

E . Determine the Site Life for this land application site:

The lifetime loading rate shall not be exceeded. The site life calculations will be based on the most restrictive crop plant available nitrogen (PAN) requirement specified and the maximum dry tons of residuals to be land applied annual.

In the table below, the highest annual loading (Tons of Residuals to be Applied/Acre/Year) specified above, will be multiplied by the lbs/dry ton of each pollutant as found in **B**. The Site Life can be determined by:

☛ **Site Life (Years) = Allowable Lifetime Loading (lbs/acre)**
Projected Pounds to be Applied/Acre/Year

Pollutant	Residuals to be applied (tons/ac/yr)		lbs/dry ton of each pollutant (as found in Part B)		Pounds to be Applied per acre/year	Allowable Lifetime Pollutant Loading (lbs/ac)	Site Life (Years)
Arsenic	9.50	*	0.0035	=	0.0333	36	= 1082
Cadmium	9.50	*	0.0080	=	0.0760	34	= 447
Copper	9.50	*	7.0000	=	66.500	1338	= 20
Lead	9.50	*	1.4400	=	13.680	267	= 19
Mercury	9.50	*	0.0041	=	0.0390	15	= 384
Nickel	9.50	*	0.0313	=	0.297	374	= 1257
Selenium	9.50	*	0.0086	=	0.0817	89	= 1089
Zinc	9.50	*	2.3200	=	22.640	2498	= 110

Compare the nine (9) pollutants above and determine which pollutant that will result in the shortest life of the site.

The Limiting Pollutant is Lead.

The Site Life is 19 **years.**

Appendix E: Sample Certification Forms

Site Suitability Certification. To minimize need for detailed site information, this certification should be completed by a soil scientist or other qualified person.

Crop Management Plan. Should be completed by an agronomist or other qualified person to expedite DHEC project review.

See following pages for sample forms ...

Certification of Site Suitability
Land Application of Wastewater Biosolids

PROJECT INFORMATION

Project Name: _____

Biosolids Generator: _____

CERTIFICATION

I hereby certify that I have personally evaluated the proposed land application sites (including evaluation of drainage ways, soils, topography, depth to groundwater) and have determined that the site is suitable for the agronomic application of wastewater biosolids — for the purpose of growing crops. This project should be effective when good management practices are followed. The fields selected are capable of normal agricultural production. I further certify that I have the professional competency to conduct this investigation. The fields that I have evaluated have been indicated on the attached maps. A description of the sites, including any recommended restrictions, is also attached.

Name: _____

Signature: _____

Title: _____

Company: _____

Date: _____

Certification of Crop Management Plan
Land Application of Wastewater Biosolids

PROJECT INFORMATION

Project Name: _____

Biosolids Generator: _____

CERTIFICATION

I hereby certify that I have personally evaluated the crop management plan for the proposed land application project (i.e., selected crops, planting/harvesting schedules, wastewater biosolids characteristics and application methods) and have determined that the plan is suitable for land application of wastewater biosolids for the selected crops and schedules. This plan should be effective when good management practices are followed. I further certify that I have the professional competency to conduct this investigation.

Name: _____

Signature: _____

Title: _____

Company: _____

Date: _____